Geodetic Network Design for Low-Cost GNSS

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Abstract

Low-cost GNSS stations, utilising 'mass-market' single- and dual-frequency receivers and antennas, allow larger networks than conventional GNSS systems at the same equivalent cost. Large (several tens of instruments) low-cost GNSS networks could complement conventional GNSS instruments and remotely sensed deformation data (e.g. InSAR), by combining the high temporal resolution and 3d measurements commonly associated with the former, with relatively high spatial resolution closer to that of the latter. Previous applications of such networks include measurement and monitoring of deformation associated with volcanoes, landslides, and urban structures; however, to-date their use for investigating tectonic deformation is limited. The combination of relatively high spatial and temporal resolution deformation measurements around continental fault zones has the potential to improve measurement and characterisation of aseismic transient deformation, for example that arise from rapid postseismic slip.

However, the main disadvantage of these low-cost systems is the reduced positional and displacement accuracy relative to conventional GNSS, particularly for single-frequency instruments. To explore the potential for monitoring slip on shallow continental faults with low-cost GNSS, we here investigate optimal network design for such systems.

We first define a non-uniform fault discretisation - splitting the fault plane into patches for data inversion- according to the trade-off between the number of patches and model uncertainty. This exercise is performed using an idealised dense regular network of stations and allows the selection of an optimal discretisation that best reflects the required model uncertainty. Unlike previous works, we do not implement regularisation and instead directly consider the model variance-covariance matrix in order to deal with the ill-conditioning inherent to the inversion problem.

Next, we use a particle swarm optimisation algorithm to find optimal and near-optimal networks of a fixed number of instruments. Networks are compared to the idealised version using a distance metric and criterion matrix method to minimise variance and covariance

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values for the model parameters.

Initial results demonstrate that low-cost GNSS stations have significant potential for measuring slip in shallow continental fault zones, but that optimal network structure is very different for single and dual-frequency instruments. Future work will aim to quantify this further, especially for single-frequency stations which provide the greatest potential for large, low-cost GNSS networks.